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SITE CONDITIONS AND SOUTHERN PINE BEETLE ATTACKS

REVISION OF A PROBLEM ANALYSIS

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SITE CONDITIONS AND SOUTHERN PINE BEETLE ATTACKSREVISION OF A PROBLEM ANALYSISIntroduction

Since the preparation of the original problem analysis concerning forest site conditions and southern pine beetle attacks (11), there have been changes in the state of our knowledge and the capabilities and goals of our project that necessitate a revision. Bennett (1) has prepared a problem analysis for the overall study of the southern pine beetle, and Hodges (9) has analyzed the problem from the viewpoint of a tree physiologist. This analysis will be devoted primarily to soil conditions as they influence the trees, principally loblolly pine (Pinus taeda L.). Duplication of effort will be avoided wherever possible, but the problem must be considered in relation to the primary concern and ultimate goal of the research project: to obtain an understanding of the causes of southern pine beetle outbreaks and the eventual application of this knowledge to prevent or effectively control depredations of this pest.

The Problem

Outbreaks of the southern pine beetle recur at irregular intervals over the Midsouth in more or less well defined areas. The flatwoods of southeast Texas, and in recent years southwest Louisiana, the loessial hills and terraces of southwest Mississippi, and the mountainous terrain of northern Alabama, are zones in which the southern pine beetle has repeatedly caused great losses of standing timber. Bennett (1) has

indicated the economic importance of these losses and the need for adequate measures to prevent future outbreaks or to effectively control infestations that do occur.

Obviously, the soil conditions vary greatly from the flatwoods of the lower Coastal Plain to the mountains. The probability is quite low that one or two soil properties are related to tree susceptibility to bark beetle attack in the diverse zones. Within each recognized problem area there may be a set of circumstances that favors the development of bark beetle outbreaks. Hodges (9) has pointed this out in his analysis, and also has stated that the causes of outbreaks may vary in time within the same problem area. In the flatwoods, for example, it is conceivable that the vigor of loblolly pine (the principal susceptible species) may be reduced by excess soil water throughout the spring; likewise, a severe drought in midsummer could cause loss of tree vigor. Or, a combination of the two is quite possible and might result in reduced tree vigor followed by a bark beetle outbreak. One must assume that tree vigor is related to resistance to bark beetle attacks and that some meaningful measures of vigor can be found. No matter how unfavorable conditions may be for the host tree, however, there are other necessary requirements for bark beetle outbreaks. In other words, the complete system must be considered in evaluating causal relationships between bark beetles and their hosts, and the environmental factors that affect both.

Studies of soils and site conditions in relation to the southern pine beetle problem should develop a general fund of knowledge that would enable an accurate interpretation of the effects of environmental factors on trees. As knowledge of the soil properties is gained in each problem

area, studies can be initiated to evaluate their possible relationship to tree physiology.

Some soil properties are generally recognized as having direct or indirect effects on plant growth --structure and mechanical, mineral, chemical, and organic composition. The relative importance of these properties to tree vigor will vary greatly in space and time. Some basic knowledge about them must be accumulated before any useful evaluations can be made.

It is probable that soil properties per se have little bearing on the physiological condition of host trees. However, the combination of soil conditions and tree responses may add up to a situation that favors successful bark beetle attacks. Knowledge of soils will permit a more complete and satisfactory appraisal of the entire system --trees, environment, and bark beetles.

#### Existing Knowledge

Chapman (5) and Raney (15) discuss soil chemical and physical properties and their interrelationships with plants and soil microorganisms. Their discussions are helpful in the use of existing knowledge concerning properties of the most common soils in the Gulf States. Also, generalized soil maps are available for individual counties in Texas, Louisiana, Mississippi, and Alabama through the Soil Conservation Service.

Lorio (12) used county soil maps in conjunction with field observations to study the relation of bark beetle outbreaks to soil conditions in southeast Texas. Two soil series, Rains and Caddo, were frequently associated with stands attacked by beetles. Virtually all outbreaks

in the area studied were on imperfectly or poorly drained soils. Outstanding features about these soils are: low fertility, low organic matter content, medium to fine texture, medium to low water-holding capacity and a tendency to compact. The combination of flat topography and high rainfall provide very wet conditions over prolonged periods in the winter and spring. Severe drought often occurs in the summer and fall. It is assumed that tree root distribution is limited by prolonged wet conditions and that drought effects are intensified because roots cannot extract water from greater depths.

Entomologists and others working in southern pine beetle control in southeast Texas have observed that attacks frequently begin on flat sites. Trees on slightly elevated areas known as "pimple mounds" are often by-passed or are attacked later. The reason(s) for such a phenomenon is not clear. The slight difference in elevation may provide a significantly different site that would be more favorable for tree roots --especially during high water periods.

Lorio (14) reported a decline of loblolly pine in southwest Louisiana associated with Phytophthora cinnamomi Rands, the primary cause of littleleaf disease of shortleaf (Pinus echinata L.) and loblolly pine (3, 4). The decline is taking place in a southern pine beetle problem area, and there is evidence of a relationship between the two problems. Other pathogenic fungi (Pythium spp.) that could be contributing to the decline have been found in the soil. The wet conditions and mild temperatures in this area during the winter and spring are favorable for the spread of these "water molds" (6). The most favorable temperatures for growth of

Phytophthora cinnamomi is reported to be between 24°C. and 27°C. (8, 16).

Zentmeyer et.al. (20) report that no growth occurs below 50°F. (10°C.) nor above 93°F. (34°C) and that sporangia, which produce the important zoospores, are formed mainly between 77°F. (25°C.) and 87°F. (30.5°C).

Air temperature records are available from official weather stations and within the problem area. However, information on soil temperatures in conjunction with soil moisture studies is lacking. The establishment and duration of optimum conditions of soil moisture and temperature with respect to P. cinnamomi probably vary greatly from year to year, and may be significant to tree vigor.

Contrary to the expected condition, loblolly pine root distribution in southwest Louisiana seemed more extensive in flats than in mounds (13). Subsequent study has indicated that the root systems of trees on flat sites have few fibrous roots and a generally unhealthy appearance. The outer bark is rough and scabby and stored foods are apparently low as indicated by iodine-potassium iodide tests. The roots are very similar to "brown-patch" roots described by Jackson and Hepting (10). This condition is considered to be a symptom of malnutrition and results from the formation of periderm deep in the cortical tissue. Roots of apparently healthy trees exhibit some brown patch, but littleleaf trees have many more affected roots.

Roots in mounds have a generally healthy appearance, and the amount of fibrous roots is noticeably greater than on the flat sites. The bark is reddish-brown in color and the outer portions peel off in thin flakes. In tracing roots from mounds into the flats there is an obvious change

--the portion in the flats having considerable brown patch. These preliminary observations suggest some real differences between tree root systems on mounds and on flat sites.

Tree moisture relationships depend primarily on the ability of root systems to obtain water from the ground supply. The knowledge recently gained concerning root pathogens and the apparently poor conditions of tree root systems on flat sites gives credence to the general observations that bark beetle outbreaks start more frequently on flats than on mounds. One might hypothesize that trees on slightly elevated sites in the flatwoods are more vigorous and therefore less susceptible to bark beetle attacks.

Recent outbreaks of the southern pine beetle have occurred in East and West Feliciana Parishes of Louisiana. The soils in this area are developed on the loessial hills and terraces east of the Mississippi River. The same landscape extends northward into southwest Mississippi, an area of recurring bark beetle outbreaks. The principal soils recognized in the Feliciana Parishes where beetle infestations have been most prevalent are: Providence, Grenada, Ruston, Memphis, Loring, Lexington, Bude, Calloway, Orangeburg, and Rough Broken Lands. Drainage varies from well to imperfect. Some of these soils have fragipans that restrict water movement and root penetration.

Memphis and Grenada are the most common soil series mapped in the southwest Mississippi southern pine beetle problem area. Erosion and impeded movement of water and roots by fragipans appear to be the main problems concerned with these soils. Both soils have very high silt

content, are generally low in organic matter, have low to medium available water capacity, and are very erodable (2). Perhaps the most significant feature of either soil is the impeded drainage and resistance to root penetration caused by the fragipan, which is less than 28 inches deep in the Grenada series.

In Alabama, southern pine beetle outbreaks have occurred across the northern half of the State. Soil conditions are extremely variable due to the change from Coastal Plain to mountainous terrain. Some of the more common soils in the area are included in the Susquehanna-Savannah-Ruston and the Dewey-Decatur-Clarksville associations (17). The first group is primarily low in organic matter, medium to fine textured, medium to strongly acid, and has subsoils generally heavier than in the Norfolk-Ruston area in the southern part of the State. The second soil association is composed of soils that are largely cleared of forest. Clarksville and Fullerton occupy some forested ridges, but are not of major importance.

Two other soil associations are probably important to the problem in northeast Alabama --Hartsells-Muskingum and Talladega-Fannin, which are classed as lithosols and shallow soils (humid) (18). Hartsells soils are largely devoted to agricultural crops, but Muskingum is mainly forested, and is on slopes. The subsoil is very thin or lacking and sandstone and shale come close to the surface --frequently outcropping. The Talladega-Fannin association includes soils on rough and broken areas and those on smoother relief with slightly heavier subsoils. Some soils contain considerable mica from the parent materials and are characterized by a smooth, greasy feel. Drainage is good to excessive.

It is obvious from this brief discussion concerning soils associated with forest stands subject to bark beetle infestation, that similarities among the areas are not outstanding. In each soil association area, however, there are soils that have some characteristics important to water availability and root growth. For the present, studies have been limited to one problem area for several reasons. Location of the area and facilities for conducting studies have been important factors. In addition, it is considered more feasible for the tree physiologist, entomologist, and soil scientist to concentrate on limited, well defined problems than attempt to encompass studies spread over several states at one time. Knowledge gained in one area will be helpful in planning future studies in other problem areas.

#### Research Attack Proposed

To effectively contribute to the team approach to the southern pine beetle problem the soil scientist should work cooperatively and in conjunction with both the tree physiologist and the entomologist.

Since 1962 one independent study by Lorio (12) and one short-term study by Whitmore and Lorio (19) have been completed. A soil moisture regime study (13) and a controlled soil-moisture study are in progress (15).

Current studies are located in the West Bay Game Management Area, Allen Parish, La., where the Southwestern Improvement Co. has provided 20 acres of land for studies related to the southern pine beetle problem. This work is supplying data on rainfall, relative humidity, temperature, soil moisture, water table, soil physical and chemical properties, and tree growth that will be useful to all members of the research team.

Particularly, the soil moisture, rainfall and relative humidity data will be immediately useful in evaluating the controlled soil-moisture study.

A byproduct of the moisture regime study has been the recognition of a decline of loblolly pine associated with root pathogens in the West Bay Game Management Area. A relationship between the decline and the recurrence of the southern pine beetle in this and similar problem areas is suggested.

Bennett (1) has listed the specific studies related to site and host-physiological relationships according to their priorities. Current studies are high on the list and because of staff limitations additional studies are not in immediate prospect. The studies that involve soil investigations are:

1. Soil moisture regime under loblolly pine in a southern pine beetle problem area (SO-2203-6.3).
2. Physiological changes in plant tissue in response to soil-moisture regime (SO-2203-6.5).
3. Soil, soil fungi, and root conditions associated with loblolly pine decline and southern pine beetle outbreaks.
4. Time effects of drought and flooding on recovery of pines to full vigor.
5. A comparison of site, environmental conditions, and the morphology and physiology of host trees in beetle-hazard areas and areas where outbreaks do not occur.
6. Site, tree morphology, and tree physiology in relation to beetle attack.

These titles are sufficiently broad to permit variation in emphasis based on new knowledge gained as progress is made in the team approach. More specific studies may be desired under any one title. For example, a cooperative study with Northwestern State College, Natchitoches, La. may be possible on the mycorrhizal symbionts of loblolly pine in the flatwoods of South Louisiana (their relationship with soil conditions, southern pine beetle outbreaks, and tree decline).

These proposals stress attempts to gain knowledge that is fundamental to the future development of effective practical controls. They are limited to present needs and future goals in the light of our state of knowledge. Constant developments in research techniques, instruments, and materials are increasing opportunities for investigations in diverse fields. At this time it is not possible to adequately assess the course applied research will take in order to meet final objectives. Future revisions of the analysis will define the necessary studies.

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